capable of acting the part of independent grains whose only property was to keep their shape. This was not inconsistent with dilatancy in ether, for these physical properties were possessed by the molecules of matter in consequence of the presence of the ether, and hence it was not logical that the atoms of ether should possess these properties.

If evidence of dilatancy were to be obtained from tangible matter, it was to be sought on the most commonplace, and what had hitherto been the least interesting, form, that of hard, separate grains—corn, sand, shot, &c.

That an important geometrical and mechanical property of a material system should have lain hid for thousands of years, even in sand and corn, was such a striking thought that it required no small faith in mechanical principles to undertake the search for it; and, though finding nothing but what was in accordance with previous conclusions, the evidence obtained of this long-hidden property was as much a matter of surprise to the lecturer as it could be to any of the audience.

To render the dilatancy of a mass of grains evident, it was necessary to accomplish two things: (1) the outside grains must be controlled so that they could not rearrange, and this without preventing change of shape or change of bulk; (2) it was necessary to adopt means of measuring the change of bulk or volume of the mass or of the interstices between the grains as its shape was changed. A very simple means—a thin india-rubber bag—was found to answer both these purposes to perfection. The outside grains indented themselves into the india-rubber, which prevented their changing their places, while the impervious character of the bag allowed of a continuous measure of the volume of its contents by measuring the quantity of air or water necessary to fill the interstices.

In these experiments neither the bag nor the fluid had anything to do with the dilatancy of the contents considered as forming part of a continuous medium, the bag merely controlling the outside members as they would be controlled by the surrounding grains, and the fluid merely measuring or limiting the volume.

India-rubber football cases were then shown full of dry sand, shot, corn, and glass marbles, shaken down into their densest form. The bags could not be distorted, as by squeezing between two plates, without enlarging the interstices between the grains, and hence the volume of the bag. Such increase of bulk was not, owing to the change of shape, evident to the eye; but by connecting the mouth of the bag to a pressure-gauge, it appeared as the squeezing began, the pressure of the air within the interstices began to diminish, and as the squeezing went on diminished as much as 6 inches of mercury, which showed that the interstices had increased a third. These experiments were introduced mainly to prevent the impression that the character of the fluid within the interstices had anything to do with dilatancy. Water affords a more definite measure of volume than air. This was shown. A bag holding six pints of sand full of water without air, connected by a tube with the bottom of a vessel of water, drew, on being squeezed, about a pint of water from the vessel into the bag. This was the maximum dilation; for further squeezing the water ran back into the vessel, and then again, for still further squeezing, was drawn back again, showing that, as the change of form proceeded, the medium passed through maximum and minimum dilations.

The most striking evidence of dilatancy is obtained from the fact that, since dilatant material cannot change its shape without increasing in volume, by preventing change of volume all change of shape is prevented. By closing the communication between the bag and the vessel of water, and thus preventing further increase of volume, further change of shape was instantly prevented. Starting with the sand at its densest, and the communication closed, a pinch of 200 lbs. was put on the planes without producing the smallest apparent change in the spherical shape of the bag.

Communication with the pressure-gauge was then opened, which showed that, so far from the water in the bag being at a greater pressure than the atmosphere, it was less by 20 inches of mercury, so that a little more pressure on the planes and a vacuum would have been formed. On opening communication with the water the bag instantly responded by change of shape, and again instantly stopped when the supply was cut off.

That the thickness of the envelope was of no importance so long as it was impervious to air, was shown by using india-rubber ba oons, so thin that the sand could be seen through them; one of these, which was soft and yielding when the water was in excess, became hard like a cannon-ball when the excess of water was drawn off, maintaining any shape it had when the bag was closed, supporting 200 lbs.

In this way a cast was taken from a mould, into which the bag was shaken with water in excess till it took the form of the mould; the excess of water was then drawn off, and the mould removed, leaving an image which preserved its shape loaded with 200 lbs.

The firmness and softness of the sand by the sea was shown to be due to these causes; as the tide falls it leaves the sand apparently dry, but in reality full of water, the surface of which is kept up to the surface of the fine sand by capillary attraction. This saturated sand cannot yield to the tread without dilating, and cannot dilate until it has had time to draw more water, the first effect of the foot being to draw down the capillary surface, leaving the sand apparently dry round the foot. This was shown by experiment.

The lecturer then indicated how the property of dilatancy in a continuous medium would render it capable of causing an attraction between bodies at a distance, like gravitation, and cohesion, and elastic forces between bodies close together; how the ability of the grains to rearrange at a free surface would allow bodies to move freely in the medium which, if in a state of agitation by transverse waves in all directions, would transmit waves like those of light, but not like sound, and which if consisting of grains of two different sizes or shape, would give rise to phenomena resembling those of electricity.

In conclusion, it was remarked that, promising as this dilatant hypothesis of ether was, it could not be taken as proved until it had been worked out in detail. This would take long, and in the meantime it was put forward to add interest to the property of dilatancy, to the discovery of which it had led. The property of dilatancy once recognised was, however, independent of any hypothesis, and seemed to have opened up a new field for philosophical and mathematical research quite independent of the ether.

SOCIETIES AND ACADEMIES

LONDON

Royal Microscopical Society, February 10.—The President, Rev. Dr. Dallinger, F.R.S., in the chair.—The President referred to the loss sustained by the death of Mr. P. H. Lealand, to whom microscopists were so largely indebted for the optica productions which were so well known and appreciated.—The Report of the Council was read and adopted.—Dr. Dallinger then gave his annual address, in which he detailed the results of his later researches into the life-history of minute septic organisms as carried on by means of the improved lenses constructed for him by Messrs. Powell and Lealand. Four forms were selected for study. Each of these septic organisms terminate a long series of fissions with what is practically a generative act of fusion. The two last of a long chain of self-divided forms fuse into one, become quite still, and at length the investing sac bursts, and a countless host of germs is poured forth. The growth of these germs into forms like the parent was continuously watched, showing gradual enlargement, and ultimate, but as to time somewhat uncertain, appearance of the nucleus, and the somewhat sudden appearance of the flagella or thread-like motor organs, the latter being found in each instance to arise in the nucleus. Very soon after the adult stage is reached the act of self-division commences, and is kept up for hours in succession. The delicate plexus-like structure becomes aggregated at one end of the nucleus, leaving the rest perfectly clear, except that a faint beading is seen in the middle line, with two or three finer threads from it to the plexus. Then occurs the commencement of partition of the nucleus, followed by a slight indication of division of the body-substance. Quickly afterwards the nucleus becomes completely cleft, and the body-substance follows suit. Then the plexus-like condition is again diffused equally over the whole nucleus. When the generative condition is approached by the last generation of a long series of dividing forms, it is remarkable that the organism becomes amœboid, showing how far-reaching is the amœboid state. In this condition, when two such forms touch one another they coalesce and fuse into each other almost as though two globules of mercury had touched, until nucleus reaches nucleus and the two melt into one, and the blended bodies become a globular sac, which ultimately emits an enormous number of germs. Previous to the blending it is now made out that all

traces of plexus-like structure are lost in the nucleus, which becomes greatly enlarged and assumes a milky aspect, and shows no trace of structure throughout the process of fusion. Afterwards it begins to diffuse itself radially through the body-sarcode, until every trace of the nucleus is gone, and the still globule of living matter becomes tight and glossy, but no trace of structure can be anywhere found in it. In this condition it remains for six hours, when it emits the multitude of germs. After giving similar details about several other organisms, Dr. Dallinger summed up thus:—"One thing appears clear; the nucleus is the centre of all the higher activities in these organisms. The germ itself appears to be but an undeveloped nucleus, and when that nucleus has attained its full dimensions there is a pause in growth, in order that its internal development may be accomplished. It becomes practically indisputable that the body-sarcode is, so to speak, a secretion, a vital product of the nucleus. From it the flagella originally arise; by it the act of fission is initiated and in all probability carried to the end; the same is the case with fertilisation and the production of germs. We are thus brought into close relation with the behaviour of the nucleus in the simplest condition. No doubt far profounder and subtler changes are concurrently proceeding. We of course are no nearer to the solution of what life is. But to come any distance nearer to a knowledge of how the most living part of the minutest organisms acts in detail has for me, and for most biologists, an increasing fascination." The address was illustrated by the aid of the oxy-hydrogen lantern.—The new Council was elected, Dr. Dallinger being elected President for a third term.

BIRMINGHAM

Philosophical Society, February 11.—On Resistance at surfaces of electrodes in electrolytic cells, by G. Gore, LL.D., F.R.S. This paper is a purely experimental one, and contains new proofs of some of the chief results of an extensive research on "transfer-resistance," communicated to the Royal Society, March 2, 1885 (*Proc.* Roy. Soc., 1885, No. 236, p. 209). In it the author shows conclusively that the phenomena discovered by him, and to which he applied that term, are not due to polarisation, some kind of electromotive force, or any other form of opposing difference of electric potential, because they still remain when those causes are entirely absent. He selected various cases of voltaic inversion, in which a pair of different metals in an exciting electrolyte produced no difference of electric potential and no voltaic current, and examined them for "resistance" and differences of "resistance" at the immersed surfaces of the two metals. He first tested them by a "bridge" method, and then by a "condenser" one, also described, and gives the results; and in every case he found that the "resistance" still existed, and was different in amount at the two plates. In each case the plates were of equal sizes. He also took several cases in which a pair of plates of the same metal, but of different sizes, were immersed in an exciting electrolyte, a combination which it is well known produces no difference of electric potential and no voltaic current, and tested them similarly, and found abundant evidence of "resistance," different in amount at the two plates in each instance. By the condenser method he also measured the amounts of such "resistance" at the surfaces of the two different metals, of several voltaic elements at their inversion-points, during absence of difference of electric potential, and gives the quantities. He asks: "Is the phenomenon I have discovered really of the nature of ordinary electric conduction-resistance? If it is, its characters will agree with the most essential ones of that influence. It agrees in several important points with that resistance: first, it is not able to produce a current; second, it is usually small with those liquids in which ordinary resistance is small; and third, it is considerably reduced in liquids by rise of temperature, it also, when overcome by current, evolves heat" (*Proc.* Roy. Soc., 1885, No. 236, p. 209; *Phil. Mag.*, vol. xxi. 1886, pp. 130–148). It differs, however, from such resistance in the less important circumstance that it varies in amount with the strength and density of the current; it is also usually much larger in amount than the ordinary conduction-resistance of a short section of the same liquid. "From these various fundamental truths respecting it, 'transfer-resistance' is a retarding influence essentially similar to ordinary conduction-resistance, but modified, increased in amount, and rendered more complex by taking place at the surfaces of mutual contact of two heterogeneous bodies instead of in the mass of a homogeneous substance." He concludes by remarking that "it performs an important part in the action of all voltaic batteries and electrolytic cells," and calls attention to the circumstance that "one important practical application" of it "has been made in the electro-metallurgical purification of copper on the large scale, where a great saving has been effected by arranging the depositing vats in multiple series, and thus diminish the 'transfer-resistance.'" It was in the year 1831 that the first attempt to discover this kind of resistance was made by Fechner.

PARIS

Academy of Sciences, February 22.—M. Jurien de la Gravière, President, in the chair.—Observations of the small planets made with the great meridian instrument of the Paris Observatory during the fourth quarter of the year 1885, communicated by M. Mouchez.—Determination of the elements of refraction: examination of the general geometrical conditions required to be fulfilled in the practical solution of the problem, by M. Lœwy. The question is treated under the three following heads:—(1) Given the positions of two stars, at what time of the day must the conjugated operations be effected in order to attain the greatest variation of refraction? (2) What angle of the double-mirror is most suitable for obtaining this maximum value? (3) What are the co-ordinates of the two stars enabling the observer to arrive at the maximum effect of the refraction in the minimum of time?—Experimental verification of Verdet's optical law in the directions near those that are normal to the magnetic lines of force, by MM. A. Cornu and A. Potier.—Specific determination of the imprint of fossil plants in the Carboniferous formations of the Gard, with a view to determining the sequence of the vegetable species and of the stratified rocks in this basin, by M. Grand'Eury.—On the equivalent of the terbines, by M. Lecoq de Boisbaudran.—Remarks on M. Jean Luvini's note on the subject of the conflicting theories advanced by M. Faye and his opponents to explain the action of water-spouts, whirlwinds, and analogous atmospheric phenomena, by M. Léon Lalanne. The author mentions two authentic cases which occurred on the west coast of France many years ago, and which seem inexplicable except on the supposition of *a transverse ascending movement.*—Note on the employment of dynamometric machines for the transmission of force at the marine cannon foundry of Ruelle, communicated by M. Jurien de la Gravière.—Observations of Barnard's comet made at the Imperial Observatory of Rio de Janeiro, by M. L. Cruls. These observations, made with the 0·25m. equatorial, extend over the period from July 15 to August 8, after which date the comet became invisible.—Observation of the nebula in Andromeda made at the same Observatory during the period from September 10 to December 18, 1885, by M. L. Cruls. The angle of position between the *nova* and the central nucleus of the nebula, as well as the angular distance, was measured on two separate occasions, with the following results:—

	Angle of position	Estimated distance
	°	″
September 17 ...	80·9 ...	15·0
October 28	79·1 ...	12·1

—Observation of the meteoric display of November 27, 1885, made at the same Observatory, by M. Cruls. The total number of meteors observed between November 26-29 was 1792, the maximum being on November 27, when 73 were seen in five minutes and 1145 during the whole night.—Results furnished by the observation of the solar protuberances at the Roman Observatory during the year 1885, by M. P. Tacchini. The great protuberances were never seen in the neighbourhood of the Poles, but nearly always between the equator and ± 40°, corresponding almost invariably with solar regions free from spots and faculæ. As regards the protuberances, solar energy may be considered as having been more active in 1885 than during the previous year.—Phosphorographic studies for the photographic reproduction of the stars, by M. Ch. V. Zenger. The author describes what he hopes may prove to be an improvement even on MM. Henry's process, which has already yielded such surprising results. He uses the phosphorescence of the sulphurets of the alkaline earths instead of the fluorescence in the preparation of his photographic plates, thereby securing greater sensitiveness and power to reproduce the invisible as well as the visible stars.—Determination of the remainder in Gauss's quadrature formula, by M. P. Mansion.—Note on a geometrical interpretation of the differential equation—

$$L\left(x\frac{dy}{dx} - y\right) - M\frac{dy}{dx} + N = 0,$$

in which *L*, *M*, and *N* denote functions of *x* and *y* at once homogeneous, algebraic, entire, and of the same degree, by M. G. Fouret.—On the coefficient of contraction of elastic solid bodies, by M. Gros.—Analysis of some specimens of the air taken at Cape Horn by the Mission sent to observe the transit of Venus, by MM. A. Muntz and E. Aubin. The mean result of the analysis gave 20·864 as compared with 20·960, Regnault's mean for the atmosphere of Paris. The proportion of oxygen appears to be also very nearly equal to that of the air in various other parts of the globe, so that the variations in the quantities of nitrogen and oxygen in the whole terrestrial atmosphere seem to oscillate within very narrow limits, as was already shown by Regnault in the course of his memorable researches.—Action of gaseous hydrochloric acid on iron, by M. F. Isambert.—Fresh researches on the earthy alkaline manganites, by M. G. Rousseau.—On the reduction of compounds optically inactive by the process of compensation, by M. E. Bichat.—Observation in reference to M. Joly's note on the titration of the phosphoric acids by means of various indicators, by M. R. Engel.—Note on the formation of monatomic alcohols derived from the essence of turpentine, by MM. G. Bouchardat and J. Lafont.—On the action of the alcoholic chlorides on ammonia at a low temperature, and on the methylic amines, by MM. Camille Vincent and Chappuis.—Note on lesions of the alcoholic nevrite, by M. Gombault.—On the *Balanoglossus sarniensis*, by M. R. Kœhler.—On the morphology of the ovary in insects, by M. Ad. Sabatier.—Note on the nervous system of *Echinus acutus*, by M. Henri Prouho.—Note on *Diplosoma Kœhleri*, a new species of Diplosomian recently found in Guernsey, by M. F. Lahille.—On the quantities of heat liberated and absorbed by plants, by M. Gaston Bonnier.—Note on a nephelinic tephrite from the valley of the Jamma, kingdom of Shoa, by M. A. Michel Lévy.—Note on the basaltic rocks of the county of Antrim, Ireland, by M. A. Lacroix.—On the Egyptian decans, by M. Omont.

Berlin

Physical Society, December 18, 1885.—Dr. Schulze-Berge spoke on the conduction of electricity in dielectric media, a subject which had hitherto been examined in most cases only from a technical standpoint, in order to determine the insulating power of gutta-percha sheathings for telegraph wires and cables. If it were assumed that the resistance of the dielectrics differed with the thickness of the layer according to the same law as prevailed in metals, then—seeing that the resistance of a cubic centimetre of gutta-percha was, in accordance with Jenkin's determinations, equal to 25×10^{12} ohm—the thickness of a layer, the resistance of which amounted to about 100 ohm, and ought to be measurable, must be so small as to be incapable of being produced. It might possibly be the case, however, that in dielectrics the resistance varied in another relation to the thickness, and in point of fact the speaker had found that a gutta-percha layer of 1/13 mm. thickness, and a superficies of 175 square c.m. inserted between two metal plates into the circuit of a Daniell's element connected to earth, produced a very rapid discharge. Measurements executed by the speaker by means of a quadrant-electrometer on thin layers of gutta-percha, sulphur, paraffin, and sealing-wax between two metal plates, yielded resistances very well capable of being measured, and which in the case of gutta-percha amounted on an average to about 200 ohm. In the case of sulphur the values varied between 20 and 2000 ohm, and just as varied and irregular were the resistances in the case of the two other substances. The layer offering resistance was produced by placing rubber tissue or purest flowers of sulphur on a heated plate of zinc, and thereupon pressing the second heated metal plate, after which the whole was allowed to cool. In the course of time the resistance changed. In the case of sulphur it increased, in the case of paraffin and sealing-wax, however, the resistance abated; in the case of gutta-percha the resistance continued pretty equal. If the cells supplying the current were disconnected, and the dielectric brought into conjunction alone with the electrometer, then the latter showed no deviation, whence it was inferred that the dielectric did not conduct electrolytically, and that it was no electrolytic polarisation which caused the change of resistance. The measurements of resistance were also taken with the aid of the Wheatstone bridge, and, after the former results had been confirmed by this method likewise, the influence of the electromotive force on the resistance of the dielectrics was determined. If the bridge system was in equilibrium, then must it remain unaltered when the intensity of the current was varied by the insertion of a changeable resistance into the circuit of the current. The experiment, however, showed that with the change in the strength of the current the needle of the galvanometer indicated a deflection. This change of resistance with the change in the strength of the current was, as the speaker had become convinced, by means also of the bridge combination, through disconnecting the chain, not caused by an electrolytic polarisation, but probably by a dielectric polarisation, which would have to be further investigated after other dielectrics, besides the four mentioned, had been tested. The most important results of his experiments were formulated by the speaker as follows:—(1) The resistance of the dielectrics varied in relation to the thickness of the layer in a different way from metals. (2) The conduction of the dielectrics was not electrolytical. (3) The resistance depended on the electromotive force.—In the discussion following this address, Dr. Schulze-Berge further stated that the sensitiveness of his electrometer was so great that a Daniell gave a deflection of 120°.—Prof. Schwalbe gave a full report of the two volumes on "Geophysik," by Herr S. Günther, published last and this year.

BOOKS AND PAMPHLETS RECEIVED

"Gurina im Obergailthal (Kärnthen)": A. B. Meyer (Hoffmann, Dresden).—"Das Gräberfeld von Hallstatt": A. B. Meyer (Hoffmann, Dresden).—"The Chemistry of the Coal-Tar Colours": R. Benedikt, translated by E. Knight (Bell and Sons).—"Der Schall": Dr. Elsas (Freytag).—"Photo-Relief Map of Scotland": H. F. Brion and Rev. E. McClure (S.P.C.K.).—"Flowers, Fruits, and Leaves": Sir J. Lubbock (Macmillan and Co.).—"Les Aérostats Dirigeables; leur passé, leur présent, leur avenir": B. de Grilleau (Dentu, Paris).—"Führer f. Forschungsreisende": F. F. von Richthofen (Oppenheim, Berlin).—"Tourist's Guide to the Flora of the Alps": Prof. K. W. v. Dallatorre (Sonnenschein and Co.).—"Hand-book of Mosses": J. E. Bagnall (Sonnenschein and Co.).—"The Laws of Nature": S. Cockburn (Sonnenschein and Co.).—"The Elements of Economics," vol. ii. part 1: H. D. McLeod (Longmans).—"Manual of Music": R. Dunstan (Hughes).—"Meteorologische Beobachtungen in Deutschland, 1883," Jahrgang vi. (Hamburg).—"Bulletin of the U.S. Geological Survey," Nos. 7 to 14 (Washington).—"Annual Report of the Comptroller of the Currency U.S., December 1, 1885" (Washington).—"Report of the International Polar Expedition to Point Barrow, Alaska": Lieut. P. H. Ray (Washington).—"On the Structure of the Brain of Sessile-Eyed Crustacea": A. L. Packard (Washington).

CONTENTS